

## PRODUCTION SERVER FOR AUTOMATED CONTROL OF PRODUCTION DOCUMENT MANAGEMENT

### Field of the Invention

5 The present invention relates generally to a document production server and more particularly to coordinating production of document processing jobs in a print shop.

### Background of the Invention

Conventional print shops are organized in a manner that is functionally independent  
10 of the print jobs, the print job mix, and the total volume of print jobs passing through the system. Most commonly, equipment that is somewhat related is grouped together on a factory floor. This causes all printing equipment to be grouped in a single locale and for example, all finishing equipment to be grouped in a separate locale. In other words, conventional print shops typically organize resources into separate departments, each  
15 department corresponding to a particular process that is performed in completing a print job.

When a print job arrives, the print job sequentially passes through each department. Once the print job is completely processed by a first department, the print job is placed in queue for the next department. The queue is sometimes in the form of a temporary storage  
20 facility. This process continues until the print shop makes its way through each department and is completed.

There are a number of limitations with conventional print shops. For example, the equipment employed in conventional print shops is not well interfaced with internal computer  
25 systems. In addition, the equipment is often physically organized in an inefficient arrangement. Typical arrangements employ machines that require operators to load/unload jobs, monitor job progress, pass jobs on to a next station, and commence a next job. In between each of the steps, each job is commonly stored in a storage area awaiting the next step of the job. As a result, excess inventories may buildup and add to the costs of the job. A  
30 physical job card is used to track progress of a job. The job card specifies the steps needed to be completed to finish the job. The job card also specifies the steps already completed, and the order in which steps are to be performed. The data regarding job completion is manually added to the job card, or sometimes is only remembered by the operators working on the job.

The lack of real time information concerning the contemporaneous state of the machines and the jobs leads to less efficient plant utilization, and lower productivity. Further, large jobs cannot easily be split into more efficient smaller job lots due to the difficulty in tracking the smaller job lots.

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### Summary of the Invention

For the foregoing reasons, there exists in the art a need for a more efficient strategy to producing print jobs. The present invention provides a solution to the above-described problems by providing a system and method for coordinating production of document 10 processing jobs among a plurality of autonomous cells. A “cell” comprises at least one device for completing the document processing jobs.

In accordance with one example embodiment of the present invention, a printing workflow system is disposed in a network for coordinating production of document 15 processing jobs. The printing workflow system is comprised of a plurality of cells, where each cell is comprised of at least one device for completing the document processing jobs.

The printing workflow system may include a workflow mapping module that determines a workflow of the document processing jobs. The printing workflow system 20 additionally includes a job description module for splitting the various document processing jobs into sub-jobs. A print cell controller is provided at selected one of the cells for receiving at least one sub-job and for further splitting the sub-job into lots for processing among devices in the selected cell.

25 In accordance with an additional aspect of the present invention, a method is provided for assigning sub-jobs to available cells in a priority workflow system for printing a product-type. The method entails identifying the maximum capacity of the available cells to print the product type. The current capacity of each of the available cells to print product type is also identified. Based on the maximum capacity and current loading of each of the available 30 cells, a current capacity of each of the available cells for printing the product-type is determined. At least one of the available cells is assigned for printing.

Brief Description of the Drawings

The aforementioned features and advantages, and other features and aspects of the present invention, will become understood with regard to the following description and accompanying drawings; wherein:

5 **FIG. 1** is a diagrammatic illustration of a printing workflow system in combination with cells and their corresponding devices according to one aspect of the present invention.

**FIG. 2** is a diagrammatic illustration of software components employed in the printing workflow system of **FIG. 1**.

**FIG. 3** is an illustration of a server 20 employed in the printing workflow system.

10 **FIG. 4** illustrates the splitting of a document processing job into sub-jobs in the illustrative embodiment.

**FIG. 5** is an illustration of a capacity of a cell.

**FIG. 6** is an illustration of capabilities of a cell.

**FIG. 7** is an illustration of splitting of a sub-job.

**FIG. 8** is an illustration of a job decomposition module.

**FIG. 9** is an illustration of data structures of a document processing job.

**FIG. 10** illustrates step performed by a product cell controller.

**FIG. 11** is an illustration of assigning “kanbans” to a document processing job

**FIG. 12** is an illustration of assigning sub-jobs to cells.

20 **FIG. 13** is an illustration of assigning sub-jobs to determining the capabilities, capacities, and current loading determining the current capacity of each of the available cells.

**FIG. 14** is an illustration of the steps needed to calculate the terms and capacity of each available cell.

25 Detailed Description of the Invention

The illustrative embodiment of the present invention provides a lean production process server (LPPS) for coordinating production of document processing jobs in a document factory (such as a print shop). The server exploits lean production techniques to control document processing jobs. The server can be run on a UNIX, Windows or Window

30 NT based-platform, such as a server computer system. The server determines workflow priorities and manages workflow accordingly. Those skilled in the art will appreciate that the present invention may also be practiced with platforms that run other varieties of operating systems. Moreover, the server need not run on a dedicated computer system but rather may

run on another variety of electronic device, such as a printer, copier, etc. Workflow priorities for document processing jobs can be determined by observing the various jobs processing units.

5        The illustrative embodiment presumes that the document factory has been partitioned into autonomous cells. Each cell is a logical grouping of resources (including both equipment and manpower) in the document factory that is sufficient for completing at least one type of document processing job. Thus, a first cell may include a printer and binder whereas a second cell may include a copier and a collator. The LPPS is responsible for  
10      distributing document processing jobs in such cells in an efficient manner (as will be described in more detail below).

Referring now in detail the drawings, wherein the parts are designated by the reference numerals throughout, FIGS. 1 through 14 illustrate example embodiments of a printing workflow system and a method for assigning sub-jobs to various cells in the printing workflow system or according to the present invention. Although the present invention will be described with reference to the example embodiments illustrated in the figures, it should be understood that the present invention could be embodied in many alternative forms.

20        **FIG. 1** illustrates a printing workflow system 2 in a print shop (i.e., a document factory). The printing workflow system 2 controls a multitude of cells 4, 6, 8 connected by communication links 10 to the printing workflow system 2. The printing workflow system 2 sends information to and receives information from the cells 4, 6, 8 via the communication links 10. The cells 4, 6, 8 are comprised of at least one device 5 for assisting in completing a  
25      document processing job of a given product-type. For example, printing device 5 can be a laser printer 600 dpi and printing device 7 can be a color printer 1200 dpi. There is no dependence among cells 4, 6, 8 and their corresponding printing devices in that each operates autonomously relative to the other cells.

30        **FIG. 2** illustrates several of the software modules employed in the printing workflow systems 2. The printing workflow system 2, includes a workflow mapping module 12 that determines the workflow for selected document processing jobs. As will be described in more detail below, the workflow identifies the operational steps reserved to complete a

document processing job. The workflow also identifies the sequence of these operational steps. A job decomposition module 14 is included for splitting the document processing jobs into sub-jobs and for sending the sub-jobs to cells for completion. A product cell controller (PCC) 16 may be provided at given cells for receiving at least one sub-job to further split the 5 sub-job to be processed by a printing device in the cell. Lastly, a cell assignment module 18 is provided for assigning sub-jobs to be processed by a cell.

**FIG. 3** illustrates a server computer system 20, (i.e., LPSS) that is suitable for use in the printing workflow system 2. The server 20 includes processor 22, a storage 23, communication links 26, and an input module 24. The input module 24 is used to receive 10 input from various devices via the communications links 26. The input module 24 receives the document processing jobs on behalf of the server 20. The processor 22 executes the programming instructions on the server 20 to manage document processing jobs. The server 20 stores the instructions in the storage 23. For example, modules 12, 14, and 18 and other data are stored in storage 23. Module 16 may be executed on a separate server that is 15 particular to a cell.

In general, a print job is received and a workflow for the print job is developed by the workflow mapping module 12. The job decomposition module may split the job into sub-jobs. The sub-jobs or job are then assigned to cells for completion by the cell assignment 20 module 18. The sub-jobs may be sent to product cell controller 16 of the assigned cells, where each sub-job may be further sub divided.

**FIG. 4** illustrates the printing workflow system 2 interacting with a cell in a network provided in a print server. The product cell controller 16 for the cell receives a sub-job 48 25 from the server 20 to be further processed by the cell. The server 20 stores in its storage 23 the capacities and capabilities of each cell in the print shop to produce different product-types. For example, cell 32 in the network produces three different types of documents and cell 40 produces two types of documents. (It is quite possible that two different cells can produce similar document types. A document type is uniquely characterized by the sequence 30 of processing steps to completely finish the document) The server 20 stores this information to determine which cell has the capabilities to process a document job. The printing

workflow system 23 also stores the capacity of each cell to determine the volume of a particular product-type that a cell can produce. As stated above, the job decomposition module 14 splits a document processing job into sub-jobs to be sent to various autonomous cells for processing. The cells in the network are autonomous and can produce their

5 respective product entirely by themselves. Thus, in the example shown in Fig. 4, a document processing job is split into sub-jobs 48 and 50 that are sent to cells 32 and 40, respectively. The product cell controllers 34 and 42 send the sub-jobs 48 and 50 to devices 36, 37, 38 and 44, 45, 46 in the respective cells 32 and 40 for processing.

10 **FIG. 5** illustrates an example of how capacity is defined for a cell in the illustrative embodiment. As stated above, the printing workflow system 2 stores the capacity of each cell. “Capacity” is the maximum volume of a particular product type that the cell can produce for a time period. For example, **FIG. 5** shows capacities for 31, 33, and 34 three different product types (Product A, Product B, and Product C) The printing workflow system 15 2 updates the capacities and makes it easier to determine which cells should be assigned a sub-job.

20 Capabilities are used to determine the assignment for a cell to process a sub-job.

**FIG. 6** shows an example of the capabilities 39 stored for a cell 32. Cell 32 is capable of processing various document product-types A, B, C. Hence, capabilities 41, 43, and 45 are stored for cell 32. For example, if a user has a document of product-type D, then cell 32 would not be the choice to accomplish the processing of the document because the cell 32 does not support such a capability. The print workflow system 2, stores the capabilities for each cell in the print shop. This allows the cell assignment module 18 to examine the 25 capacities and capabilities of the cells to determine which cell to assign a particular sub-job.

20 The working mapping module 12 of the printing workflow system 2 determines the workflow for document processing jobs. Workflow is represented strategically as a tree diagram. **FIG. 7** illustrates an example embodiment of a workflow tree diagram. Once the printing workflow system 2 reviews an input document processing job, the workflow mapping module 12 generates a tree diagram representation of the document process job. the input that outlines the sequence of operations that need to be performed to complete and deliver document processing job. For example, the workflow 46 demonstrates a document

processing job to print fifty blue-type envelopes with red and black lettering and to print 1000 pages of a certain document with black lettering of two kinds of letterhead A & B. The workflow mapping module splits the fifty blue-type envelopes with red and black lettering and the 1000-page document with black lettering of two kinds of letterhead A & B into sub-

5 jobs 48, 50. Thus, creating two sub-jobs 48, 50 that are mutually independent from each other. Given that sub-job 48 requires fifty blue envelopes, 25 blue envelopes having red lettering and 25 blue envelopes having black lettering. The printing cell controller 16 further splits sub-job 48 into two lots 52, 54.

10 The workflow mapping module 12 determines workflow so that the workflow is reasonable for the cell and device arrangements. For example, if the print shop only has one printer to print blue-type envelopes with red and black lettering, then the workflow mapping would not split sub-job 50 into two lots for two print devices. The workflow mapping module 12 splits sub-job 50, which requires 1000 pages with letterhead A and B into lots 56 and 58, where 500 pages with letterhead and 500 pages of letterhead are printed. The other modules 14, 16, 18 of the printing workflow system 2 use the workflow mapping module 12 to aid in distributing sub-jobs among the various cells in the network.

20 The job decomposition module 14 of the printing workflow system 2 receives a document processing job and splits the document processing job into sub-jobs. As shown in FIG. 8, document processing job 62 is processed by the job decomposition module 64 to determine whether decomposition is appropriate. The document processing job 62 is composed of a multitude of printing requests. Dependent on the size of the document processing job 62 and the overall capacity of the cell arrangements in the network, the job 25 decomposition module 64 determines how to process the document processing job 62. In the case shown in FIG. 8, the job decomposition module 64 splits the document processing job 62 into autonomous sub-jobs 66, 68, 70.

30 The job decomposition module 64 uses workflow information created by the workflow mapping module 46 to decide how to split the document processing job 62. Once the document processing job 62 has been split, the sub-jobs 66, 68, 70 are sent to a number of cells 72, 74, 76 for further processing. The job decomposition module 64 provides a flexible way to distribute sub-jobs 66, 68, 70 to cells 72, 74, 76 in the network. For example, when

cell 72 receives sub-job 66, the cell 72 determines how to process sub-job 72 among the printing and/or finishing devices 77, 78, 79. The job decomposition module 64 decides which of the cells 72, 74, 76 will receive the sub-jobs 66, 68, 70 to efficiently process document processing job 62.

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Each document processing job 62 is composed of a set of parameters that define its structure. **FIG. 9** shows an example of some parameters for a document processing job. The document processing job 80 is comprised of a set of defined parameters 84, 86, 88, 90, 82. These parameters 84, 86, 88, 90, 82 are provided by a customer and inputted into the network 10 with or without human intervention. The printing workflow system 2 validates the document processing job 80 to ensure that the job 80 is valid and contains all the relevant parameters 84, 86, 88, 90, 82 to process it. The printing workflow system 2 parses the document processing job 80 to guarantee validity of the job. The data parameter 84 defines the due date 15 that a particular document processing job needs to completed. Also, data parameters 86 and 88 defines the quantity of a product-type to be processed in the document processing job 80 and the method of delivery (UPS or FedEx) being used to deliver the completed document processing job 80. The data parameter 90 defines the method of payment (credit card, debit, check) for the completed document processing job 80. The data parameter 90 defines any 20 special processing instructions that are not stipulated in data parameters 84, 86, 88, 90 that are additionally necessary to completely process the job. For example, sending a portion of document processing 80 to one location using one method of delivery while sending the other portion to another location using a different method of delivery.

**FIG. 10** illustrates a product cell controller (PCC). Once the cells 72, 74, 76 receive

25 their respective sub-jobs 66, 68, 70, each cell 72, 74, 76 employs its product cell controller (PCC) 116 for managing further processing of the sub-jobs. As shown in **FIG. 8**, the job decomposition module 64 performs the splitting of the job into sub-jobs and sends the sub-job information 66, 68, 70 to the respective cells. At this point, a cell 100 receives the 30 information to process one of these sub-jobs 98. The PCC 102 for the cell 100 receives the sub-job 98 for further processing. The PCC 102 further splits the sub-job 98 into lots 104, 106, 108 for processing. PCC 102 uses the workflow produced by workflow mapping module of the printing workflow system 96 of document processing job 94 to assign which devices 110, 112 to use to accomplish processing the sub-job 98. The optimal lot size is

determined by analyzing the workflow of the document processing job 114 and characteristics of its various elements. The PCC 102 has the ability to adjust the lot-size. For example, cell 98 may take the document processing job 94 size of 300,000 and split them into lot sizes of 150,000 to be distributed among the two devices 110, 112.

5 **FIG. 11** illustrates using a “kanban” (i.e., an electronic job card) assigned to a specific sub-job according to one output of the present invention. The PCC 116 uses a pull control policy where the last device in the workflow sends authorization to upstream process to supply it with the necessary input. This information is cascaded via the use of pre-specified number of kanbans per operation of a lot. For example, a device 122 may send an 10 authorization to upstream printer to supply it with job lot 118 of 300 pages to begin printing. It could be assigned 3 “kanbans” by PCC 116, while device 124 may send another authorization to upstream to supply it with job 120 or 500 pages to begin printing. Also, it would be assigned 5 “kanbans”. PCC 116 keeps track of the number of kanbans that devices 122, 124 use. Also, PCC 116 manages the maximum number of “kanbans” to use in each of the devices 122, 124. As these kanbans are freed up when lots have been processed, they become available for future authorization. The PCC 116 adjusts the lot sizes 118, 120 for better utilization by the devices 122, 124. This arrangement allows PCC more control of the utilization of devices to accomplish processing lots 118, 120.

20 **FIG. 12** illustrates using a cell assignment module to assign sub-jobs to cells. The printing workflow system 130 stores all the necessary information 132 used by the cell assignment module, such as maximum capacity, current capacity and current loading of a cell. Essentially, the print workflow system 130 updates all the necessary information 132 of cells 138 140 142 if there is adding or removal of devices in a particular cell. Having the printing workflow system 130 update all of the necessary information 132, allows cell 25 assignment module access to updated information without retrieving such information from the cells 138, 140, 142 and 134. The cell assignment module 136 follows various steps before the determination of which cells 138, 140, and 142 will handle sub-job 134.

30 **FIG. 13** illustrates the steps used by the cell assignment module 136 to assign a sub-job 134 to one of the cells 138, 140, and 142. As shown in step 152 the cell module needs to identify the maximum capacity of each cell to handle any sub-job. The various cells 138, 140, and 142 each have their own maximum capacity to process a sub-job 134. In step 154,

the cell assignment module 136 identifies the current loading of each respective cell. Current loading signifies the amount of work being processed by the cell at a given time. As shown in **FIG. 12**, cells 138, 140, and 142 have their respective current loading 144, 146, 148. In step 156, demonstrates based on the maximum capacity and current loading of each respective cell 138, 140, and 142 current capacities 144, 146 148 to process a sub-job.

Based on the maximum capacity and current loading of each respective cell 138, 140, 142, the current capacity of each cell at that instant moment to process a sub-job is determined. For example, cell 138 has a current loading of 1000 pages of black lettering, and 1000 pages of red lettering. The maximum capacity of cell 138 is 2000 pages of black lettering and 2000 pages of blue. At this amount, cell 138 has a current capacity to print 1000 pages more of black lettering, and 1000 pages of blue lettering. If sub-job 134 has 500 pages of black lettering and 600 page red lettering, then cell 138 would handle sub-job 134. As shown from step 158, a pull-type control policy 150 is used to assign the sub-job to the respective cell 138, 140, and 142 with the available current capacity to handle the sub-job.

15 The pull-sequence can be arbitrarily chosen in a pre-specified manner. Cell 138 can start pulling the subjobs followed by cell 140 and so on and so forth. One could choose any other sequence. In this instant, cell 138 has a current capacity for printing 1000 pages of black lettering and 1000 pages of blue lettering. Cell 140 current capacity for printing 1000 pages of black and 1000 pages of blue lettering. The printing workflow system 130 will split a 20 document processing job 128 having 2000 pages to be assigned to cell 138, 140 respectively.

**FIG. 14** illustrates using the print cell controller to administer sub-job processing when one of the devices failed during processing according to one aspect of the present invention. In the event the print cell controller 170 recognizes that it cannot deliver what it was supposed to due to unforeseen production uncertainty of an input operator availability, or 25 machine breakdown it notifies the higher level module of the printing workflow system 160 about that. The printing workflow system 160 stores the production requirement in a buffer. The system 160 is built in a manner such that whenever the print cell controller 170 determines the available capacity in the cell 168, it polls the printing workflow system buffer 162 to determine if it contains sub-jobs to be processed. Whenever the print cell controller 30 170 detects jobs in the printing workflow system buffer 162, it pulls the necessary amount of information for processing. For example, if cell 168 failed after printing 300,000 print-insert jobs wherein it was supposed to process 400,000 print-insert jobs. Print cell controller 170

corresponding to cell 168 then puts the remaining unfinished sub-job information in the printing system workflow buffer 162. Suppose that print cell controller 170 of cell 172 determines it has the capacity to process 100,000 print-insert sub-job 164. It queries the printing workflow system buffer 162 in printing workflow system 160 and determines that 5 sub-job 164 needs completion. It therefore pulls the sub-job 164 into cell 172 for processing.

Numerous modifications and alternative embodiments of the invention will be apparent to those skilled in the art in view of the foregoing description. Accordingly, this description illustrative only and is for the purpose of teaching those skilled in the art the best

10 mode for carrying out the invention. Details of the structure may vary substantially without departing from the spirit of the invention, and exclusive use of all modifications that come within the scope of the appended claims is reserved. It is intended that the invention be limited only to the extent required by the appended claims and the applicable rules of law.

Having described the invention, what is claimed as new and protected by Letters  
15 Patent is:

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